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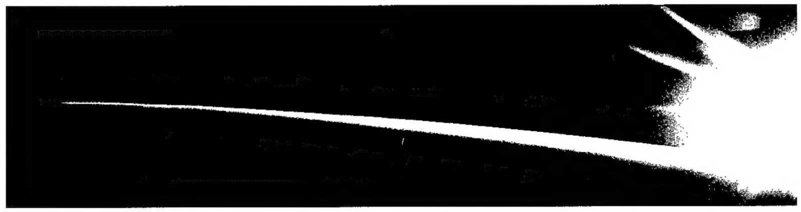
Research



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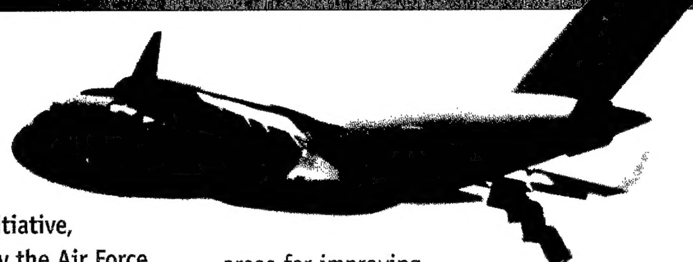
Precision Air Delivery Program



C-17 dropping Container Delivery System (CDS) bundles

A five-year research initiative, sponsored by the Air Force Office of Scientific Research (AFOSR), to explore technologies for substantially improving the accuracy of a Container Delivery System (CDS) has been successful in producing a precision air delivery capability. The initiative offers the potential for a low cost solution to the high altitude, precision challenge that will require more synergistic Air Force/ Army advancements. The program was directly motivated by the operational difficulties experienced in Bosnia and Kosovo when attempting to provide humanitarian assistance over a non-friendly territory.

The New World Vistas Precision Air Delivery (NWV-PAD) program team, led by AFOSR and the United States Army Soldier & Biological Chemical Command-Natick Soldier Center, identified the following three research areas for improving accuracy: (1) Affordable guided airdrop system, (2) All weather wind sensing, and (3) Automated computed aerial release point.

AFFORDABLE GUIDED AIRDROP SYSTEM (AGAS)

AGAS is one of three concepts being investigated for the use of controllable semi-ballistic decelerators as a low-cost, precision delivery solution. The semiballistic decelerator consists of a modified round parachute system, integrated with novel Pneumatic Muscle Actuators (fiber reinforced braided tubes that contract when internally pressurized) that provide the ability to maneuver and maintain an accurate trajectory. The concept was demonstrated via manual radio control in late 1999. A low cost guidance, navigation, and control (GN&C) system and a 2200 lbs. capacity prototype are being developed and a full scale autonomous 2200 lbs. system planned for flight-test in late summer 2000 with assistance from the U.S. Army Yuma Proving Grounds.

ALL-WEATHER WIND SENSING

Development continues to predict high resolution forecasting of wind/weather in and around a drop zone. The goal is to develop a capability to measure near real-time winds at sufficient distances from the transport aircraft to the drop zone. These measured wind speeds and directions can then be used to calculate a more precise drop point. Other USAF funded

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Precision Air Delivery Program

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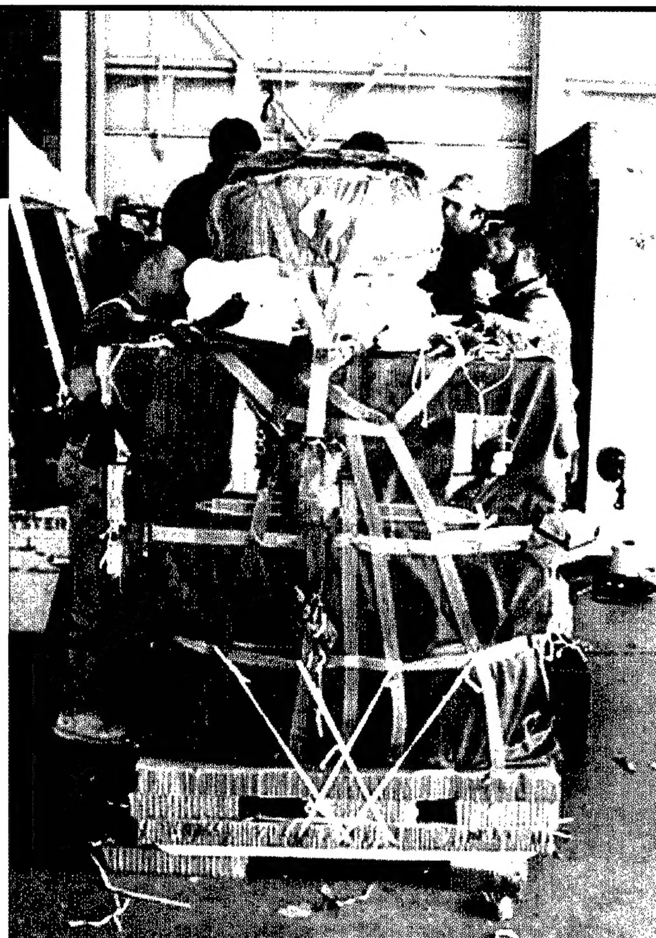
programs (such as the C-130 fuel pod-mounted, conically scanning, LIDAR program) also show significant promise for collecting near real-time winds on board transport aircraft for high altitude airdrop applications.

AUTOMATED COMPUTED AERIAL RELEASE POINT (CARP)

CARP is the third area being developed, and serves as the brains behind the whole operation. It is made up of a series of algorithms that exploit multidimensional wind/weather predictions. The CARP provides the aircraft crew with the ability to re-plan an airdrop release point as updated wind/weather data, threat information, and changes in desired impact locations become available while enroute to the drop zone.

Under this program, the NWV-PAD team is also investigating additional complimentary technologies. They include high performance computing of the fluid structure interactions associated with all airdrop systems. This work numerically couples computational fluid dynamics and structural dynamics software to predict airdrop system performance.



Rigging for airdrop of Affordable Guided Airdrop System (AGAS) with Pneumatic Muscle Actuators (PMAs)

The NWV-PAD end product is the integration of all of these efforts into a technology flight demonstration in late summer 2001. Transition of these NWV-PAD technologies to appropriate Department of Defense agencies for follow-on advanced technology demonstrations and development is being pursued with a goal of incorporation into fielded systems.

Precision airdrop will increase the survivability of United States Air Force transport aircraft and provide new supply capabilities to field commanders. The NWV-PAD technologies being developed are compatible with C-130, C-141, C-17 and C-5 aircraft and are applicable to both critical resupply of deployed U.S. forces and humanitarian relief applications.

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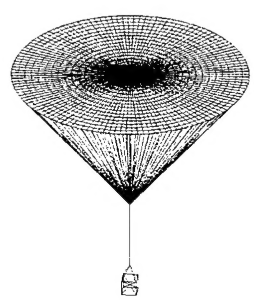
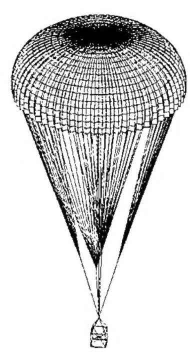
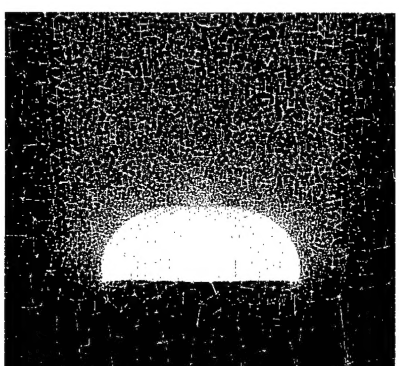


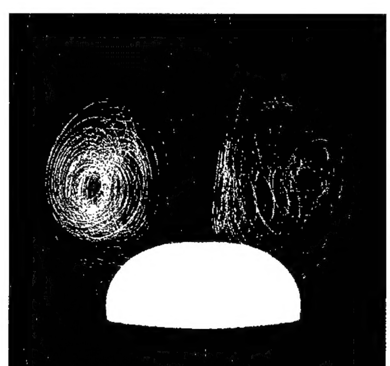
G-12 canopy "cut pattern" initial structural model geometry



G-12 canopy structural model damped with a "guess" pressure distribution

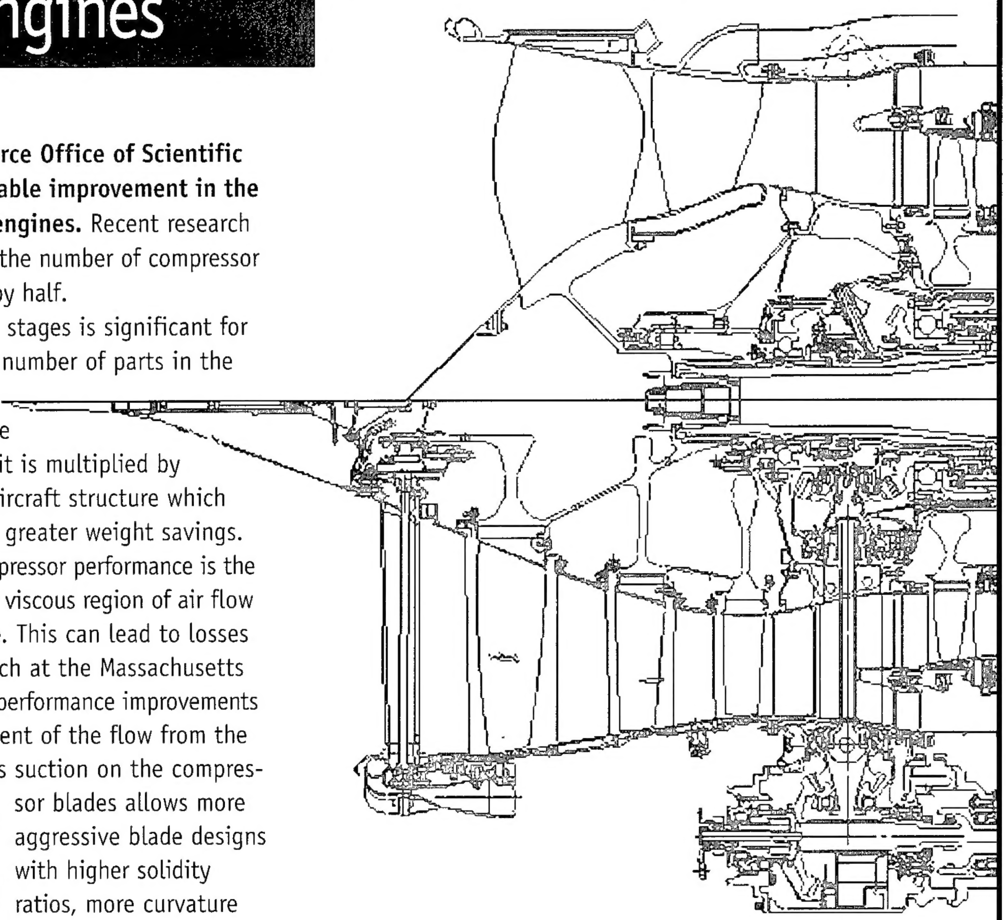


G-12 canopy fluid domain mesh (plan view cut through canopy center)



G-12 flow field (snapshot in time with rigid canopy)

Aspirated Compressor Will Reduce Size of Jet Engines

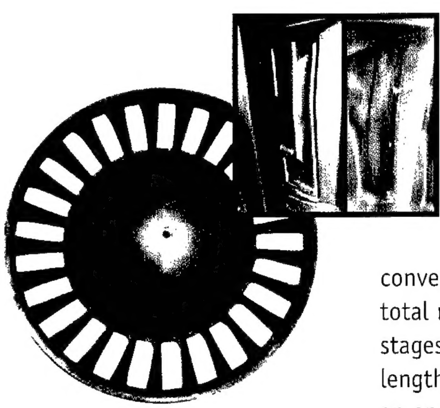


A cross-sectional drawing of the aspirated compressor design (top half) shows the significant reduction in length and number of blades compared to a conventional design (lower half).

Research funded by the Air Force Office of Scientific Research promises a considerable improvement in the performance of military jet engines. Recent research on aspirated compressors may reduce the number of compressor stages needed for an aircraft engine by half.

Cutting the number of compressor stages is significant for the Air Force, because it reduces the number of parts in the manufacturing and maintenance inventory, as well as reducing the size and weight of the engine. This benefit is multiplied by reducing weight in the surrounding aircraft structure which supports the engine, leading to even greater weight savings.

A limiting aspect of jet engine compressor performance is the tendency of the boundary layer (a thin viscous region of air flow on the compressor blade) to separate. This can lead to losses in efficiency and engine stall. Research at the Massachusetts Institute of Technology (MIT) showed performance improvements achieved by removing about 1-4 percent of the flow from the boundary layer at critical locations. This suction on the compressor blades allows more aggressive blade designs with higher solidity ratios, more curvature and longer chord lengths. This means each blade row does more work than is possible in conventional designs, so the total number of compressor stages — and the weight, length, and number of parts in an engine — can be reduced.



The aspirated compressor fan developed at MIT is shown here. The inset photograph shows a detail view of the suction slot of the fan. The thin black line on the right blade is the suction slot through which about 1% of the flow is removed. The blade on the left has the cover removed, showing the internal section channel of the blade.

This research project was started in 1993 by Dr. James McMichael as a multi-investigator effort in the turbomachinery program at AFOSR. The project, led by MIT professor Jack Kerrebrock, received Defense Advanced Research Projects Agency (DARPA) funding in 1998 for a large-scale demonstration of the concept. Collaboration with other research centers and industry, including NASA Glenn Research Center, Pratt & Whitney, and AlliedSignal engines, has been critical to the success of the project, from the development of performance estimates, aerodynamic and stress analyses, to the detail design and testing of the aspirated compressor.

Basic researchers at MIT developed analysis tools that correctly account for the effects of boundary layer flow removal and led to two different compressor designs — a low speed fan that could greatly reduce the noise and weight of turbofans, and a single high speed stage that could replace the three stages of a military fighter compressor (see drawing). Basic research efforts continue to contribute to the maturation of this technology, including more detailed analysis of the compressor performance at different operating conditions.

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ESEP Profiles

The DoD Engineer and Scientists Exchange Program, or ESEP, supports science and technology through international cooperation in military research, development, and acquisition through the exchange of defense scientists and engineers. ESEP provides on-site assignments for U.S. military and civilian scientists and engineers in foreign government organizations and reciprocal assignments of foreign scientists and engineers in U.S. government organizations. ESEP supports current USAF science and technology requirements by seeking specific foreign technologies. It provides insight into the technology and project management techniques of foreign laboratories and centers and opens areas of possible technical cooperation.

Kathleen J. Zyga

Air Force Research Laboratory
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Education:

BSEE, Clarkson University, Potsdam, New York
MBA, Rensselaer Polytechnic Institute, Troy, New York

Current Assignment:

Information Technology Division, Defence Science and Technology Organisation, Salisbury, South Australia

Description of Work:

Ms. Zyga's research assignment at the Australian Defence Science and Technology Organisation (DSTO) involves the development of new techniques for object recognition in images using neural networks. Ms. Zyga has been working on a unique multi-stage method of logo recognition for document processing which applies a generalized regression neural network to cope with variations in scale and rotation. Although there are existing systems that address the problem of logo recognition in document processing, none to date, are robust when the logo is rotated or scaled even slightly. Primarily, Kathleen has been developing workable solutions to three problems: text in the logo, all-black titles, and very small logos. She believes several difficulties still remain unexplored. For example, the current system has only a graphical output that still requires human decision-making, however simple that may be. In order to make the system truly automated, she is interested in developing a numerical decision rule to discriminate between instances of logo and non-logo recognition automatically. The current system that she works on has demonstrated a very high degree of detection accuracy, and thus has spurred the establishment of a larger program to continue and expand this research.

Research Highlights

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Research Highlights is published every two months by the Air Force Office of Scientific Research. This newsletter provides brief descriptions of AFOSR basic research activities including topics such as research accomplishments, examples of technology transitions and technology transfer, notable peer recognition awards and honors, and other research program achievements. The purpose is to provide Air Force, DoD, government, industry and university communities with brief accounts to illustrate AFOSR support of the Air Force mission. *Research Highlights* is available on-line at:

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